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HOST RANGE FOR STEMBORERS AND ASSOCIATED NATURAL ENEMIES IN DIFFERENT FARMING SYSTEMS OF KENYA

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ABSTRACT

The geographical distribution and grass host range for stemborers and their natural enemies were assessed in three districts of Kenya between June 2002 and August 2003. In each district, grasses were sampled and dissected for presence of stem borers and/or their parasitoids (natural enemies). This was done in three cropping systems; (a) maize *(Zea mays)* surrounded by wild grasses, (b) sorghum *(Sorghum bicolor)* surrounded by wild grasses and (c) uncultivated grasslands. Busia and Suba districts had the higher diversity of stemborers than Machakos district. Similarlly, parasitoids diversity was highest in Busia (24), followed by Suba (19) and the least in Machakos (9). Thirty-four species of stemborers belonging to the orders: Coleoptera [Anthribidae (1), Cerambycidae (3), Curculionidae (7), Mordellidae (3), Languriidae (3), and Tenebrionidae (2)]; and Lepidoptera [Noctuidae (6), Pyralidae (7), Cossidae (1), and Tortricidae(1)] were recovered from 31 grass species. Grass species that accounted for the highest diversity of stemborers were Hyparrhenia *(Hyparrhenia rufa)*, Barnyard grass *(Echinochloa pyramidalis)*, Guine grass *(Panicum maximum)*, Guinea-fowl grass *(Rottboellia cochinchinensis)* and wild sorghum *(Sorghum versicolor)*, Lemon grass *(Cymbopogon afronardus)*, Hyparrhenia *(Hyparrhenia rufa)*, Guine grass *(Panicum maximum)* and sporobolus *(Sporobolus pyramidalis)* were grass species with the highest parasitoid diversity.

Key Words: Coleoptera, ecosystem, Lepidoptera, parasitoids, stem borers

RÉSUMÉ

La distribution géographique et la variété des multitudes d'herbes pour les foreurs de tige et leurs ennemies naturelles était évaluée dans trois districts du Kenya entre Juin 2002 et Août 2003. Dans chaque district, les herbes étaient prélevées et disséquées pour la présence des foreurs de tige et/ou leurs parasitoides (ennemies naturelles). Ceci était fait dans trois systèmes de culture; (a) maús *(Zea mays)* entouré par des herbes sauvages, (b) sorgho *(Sorghum bicolor)* entouré par des herbes sauvages et (c) des prairies non cultivées. Les districts de Busia et Suba avaient la diversité la plus élevée des foreurs de tige que le district de Machakos. De même, la diversité des parasitoides était la plus élevée à Busia (24), suivie de Suba (19) et le moins à Machakos (9). Trente quatre espèces des foreurs de tige appartenant à l'ordre de: Coléoptère [Anthrididae (1), Cerambycidae (3), Curculionidae (7), Mordellidae (3), Languriidae (3), et Tenebrionidae (2)]; et Lépidoptère [Noctuidae (6), Pyralidae (7), Cossidae (1), et Totricidae (1)] étaient retrouvées à partir de 31 espèces d'herbes. Les espèces d'herbes qui ont compté pour la diversité la plus élevée des foreurs de tige étaient Hyparrhenia *(Hyparrhenia rufa)*, herbe Barnyard *(Echinochloa pyramidalis)*, herbe Guine *(Panicum maximum)*, herbe Guinea-fowl *(Rottboellia cochinchinensis)* et le sorgho sauvage (Sorghum versicolor), herbe de citron *(Cymbopogon afronardus)*, Hyparrhenia *(Hyparrhenia rufa)*, herbe Guine *(Panicum maximum)* et sporobolus *(Sporobolus pyramidalis)* étaient les espèces d'herbes avec la diversité des parasitoides la plus élevée.

Mots Clés: Coléoptère, écosystème, Lépidoptère, parasitoides, foreurs de tige

INTRODUCTION

Grasses comprise a diversity of plants that are among the most important to mankind. Kenya is reported to have had an abundance of grasses comprising of 587 species in 142 genera (Ibrahim and Kabuye, 1988). This fairly large number of grass species suggests that Kenya might be a centre of origin of many of the grasses found in East Africa. A few of the grass species have been selected on the basis of high forage productivity and are cultivated for livestock feed (Boonman, 1992), while the majority of species remain in the wild. However, increases in human population in the recent past, have led to the clearing of uncultivated ecosystems both in the semi-arid and humid regions for intensive and continuous cultivation of crops. This threatens grass biodiversity through extinction of some of the important grasses.

Another largely neglected aspect in biodiversity studies are insects and other arthropods, which represent about 70% of the world's biodiversity (Mohyuddin and Greathead, 1970). Understanding the diversity and ecological roles of insects in gramineous agro-ecosystems and adjacent wild grasslands is crucial in ensuring ecosystem stability. Arthropods, particularly some insects and mites, are major pests of gramineous crops and pasture plants: others, however, are major predators and parasites of these pests, and naturally control their populations (Muhyuddin and Greathead, 1970; Dwumfour, 1990). These natural enemies increase stability both in wild- and agro-ecosystems by responding to herbivorous arthropod upsurges and, thus, preventing outbreaks. Moreover, other arthropods have additional beneficial roles as pollinators of agricultural crops and wild plants, as links in food webs, and as contributors to soil quality and fertility. Although some arthropod species are shared by both cultivated and wild gramineous plants, many are specifically associated with only grass species. Therefore, loss of such wild grasses either by extinction or local extirpation around ecosystems will result into loss of their associated arthropod fauna, with potential deleterious repercussions to both wild and cultivated ecosystems.

Wild grasses on uncultivated land bordering crops can provide extremely important refugia for insect natural enemies as well as harbouring alternate hosts or prey, therefore, enhancing abundance of natural enemies which keep pest populations low. The worsening of most pest problems is linked to the expansion of crop monocultures at the expense of natural vegetation. Scientists at ICIPE in Kenya and in South Africa demonstrated the benefits of field borders of napier grass (*Pennisetum purpureum*) and Sudan grass (*Sorghum vulgare sudanense*) in the suppression of stemborers in maize and sorghum (Khan *et al.*, 1997a; Khan *et al.*, 2001; Van den Berg *et al.*, 2001). These and several other wild grasses are reported to act as 'trap plants' that attract egg-laying adult stemborers, but prevent development of their offspring, hence, providing natural control of the pests (Bowden, 1976; Khan *et al.*, 1997a; Shanower *et al.*, 1993; Van den Berg *et al.*, 2001). Other grasses like molasses grass (*Melinis minutiflora*), when intercropped with maize have been demonstrated to not only repel stemborers, but also increases stemborer parasitism by a natural enemy, *Cotesia sesamiae* (Khan *et al.*, 1997a). There is evidence that some of the herbivore damaged grasses produce volatile chemicals, which increase natural enemies and, hence, serve an important role in environmentally friendly crop protection (Khan *et al.*, 1997b). These findings show that there could be other beneficial wild grass species, which if their associated insects are known and integrated on farms for crop protection purposes, can act as a deterrent to pest infestation and damage.

The broad objective of this study was to profile the diversity of gramineae and associated insects in and around various agro-ecosystems contribute to ecosystems stability and how indigenous knowledge on grasses can contribute to biodiversity conservation. The specific objective of this study was to identify boring insects and their parasitoids associated with the different grass species.

MATERIALS AND METHODS

The study was carried out in three districts of Kenya, namely; Busia, Machakos and Suba. The selection was based on apparent variation with regard to agro-ecology, cropping system, grass diversity and ethnicity. Busia district is located at 34^0 00' and 34^0 25'E and 00^0 00'N and 00^0 45'N, and represents sub-humid to humid ecology. Machakos is located at 38^0 00'E and 38^0 45'E, and represents an arid and semi-arid ecology. Suba district, on the other hand, is located at 34^0 00'E and 34^0 15'E, and 00^0 10'S and 00^0 15'S. It represents semi-arid hot and humid ecology. The altitude ranges from 1135-1500 m.a.s.l. for Busia, and 780-1800 m for Machakos district. Suba district ranges from 1140-1800 m.a.s.l. but with over 90% of the districts at 1140-1450 m.a.s.l. The three districts have two rainy seasons, with Busia district receiving an annual rainfall of 1135-1500 mm. Machakos receives 500-1300 mm but most areas receiving 700-900 mm per annum while Suba district receives 800-1000 mm (Jaetzold and Schmidt, 1983). Farmers in Busia district grow maize, sugarcane, cotton and practice crop-livestock economy for food security and source of income, Machakos farmers grow maize, sorghum and practice pastoral economy, while those of Suba grow maize, sorghurm and also practice pastoralism. Busia district has a population of 405,388 with a density of 347 per km^2 and is occupied by the Luhya and Teso tribes. Machakos has a population of 954,084 with a density of 153 per km^2 and is predominantly occupied by Kamba tribe, while Suba district has 155,666 with a density of 147 per km^2 and predominantly occupied by Luo tribe (Ministry of Planning, Central Bureau of Statistics, 2002).

Survey of grasses for the presence or absence of boring insects and their parasitoids was carried out in Township, Matayos and Funyula divisions of Busia district; Central, Mwala and Yatta divisions of Machakos district and Central, Gwasi and Lambwe divisions of Suba district. In each division three ecosystems (1) maize *(Zea mays)* field surrounded by uncultivated grasses, (2) sorghum *(Sorghum bicolor)* surrounded by uncultivated grasses and (3) uncultivated grassland, were sampled. For maize and sorghum crops, destructive sampling was done from four quadrants per field (each quadrant 4 m x 4 m). In each quadrant, five plants (making a total of 20 plants per field) with stemborer damage symptoms were uprooted. The plants were then dissected and the borers inside removed, identified and categorised by stage (egg mass, larva, pupa) were reared in the laboratory and observed for parasitoids emergence.

For the grasses surrounding the crop fields, transect walks were made perpendicular to the crop field. A total of 4 transects, were made for each crop. On each transect five plants (stamps) of each grass species were uprooted making a total of 20 plants. From each grass stamp, five tillers that had boring insect symptoms were dissected and borers found inside recorded as for the case of maize and sorghum before being taken to the laboratory for rearing. In the uncultivated grassland, 4 transects in each field – 2 approximately north-south, and 2 east-west were made. On each transect 5, stops were made and at each stop, 2 plants (stamps) of each grass species were randomly sampled and checked for the presence of stemborers and their parasitoids. Five tillers with visible symptoms of boring insects were then dissected and the bores found inside recorded and taken to the laboratory for rearing.

In the laboratory, the recovered insects were reared on maize or sorghum stalks. Fresh stems cut into pieces of 8.75 cm long x 1 cm wide, while maintaining the posterior (older portion) node were made. Holes 4.50 cm to 6.75 cm deep were made into the stem on the side without the node. The newly collected stemborer larvae were individually transferred into the prepared stems. The individual maize/sorghum stems with larvae were then placed inside the plastic petri dish. The specimens were then left in the laboratory with feeding materials being changed as necessary for the larvae to complete pupation. Once fully pupated, the maize/sorghum stems used in rearing and all the faecal materials inside the petri-dish were removed. Clean circular news paper cuttings to fit in the petri dish were then made and placed inside each petri dish, wetted with two drops of water and the pupa placed on top of it. The stem borers were reared until adult emergence, death, or parasitoid emergence. Both the stem borers and the parasitoid that emerged were counted and identified to species level were possible.

An analysis of variance (ANOVA) using SAS (1977) was conducted to detect differences in stemborer populations between sites (districts) and the study treatments (maize surrounded by grass, sorghum surrounded by grass or grassland systems alone). Descriptive analysis using tables was used in the presentation of data on species diversity across the sites, stemborer population preferences and parasitoid diversity.

RESULTS

The average population of individual stemborer larvae or pupae recovered from stalks of maize, sorghum and wild grasses in each district was significantly (<0.05) higher in Machakos than in Suba district (Fig. 1). In Busia, the population was high but not significantly different from Machakos or Suba. The three ecosystems (maize surrounded by grass, sorghum surrounded by grass and grassland alone) did not significantly influence stemborer populations in the three districts. However, comparisons of the borer populations in a cereal crop field, the grass around it and the natural grassland ecosystems showed significant differences in different districts. In Busia, both the grass around the maize field and that in the natural grassland supported significantly ($P<0.05$) higher stemborer populations than maize alone (Fig. 2).

Thirty-one grass species consisting of 18 species from Busia, 19 Machakos, and 20 from Suba district were recorded as hosts of stembores in the different agro-ecologies (Table 1). The associated

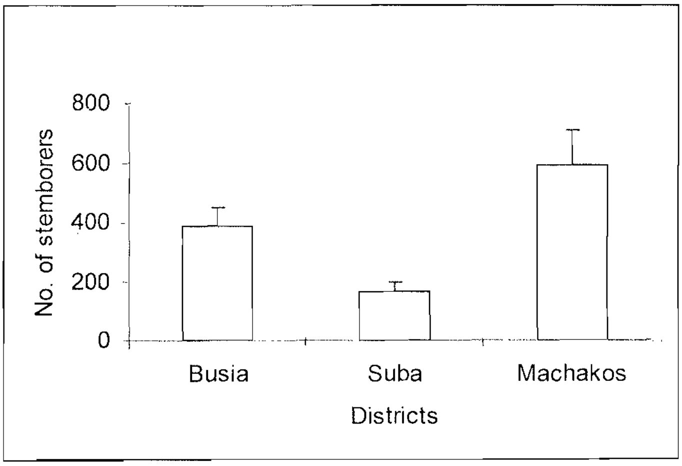

Figure 1. Stemborer populations as influenced by location per study district in Kenya.

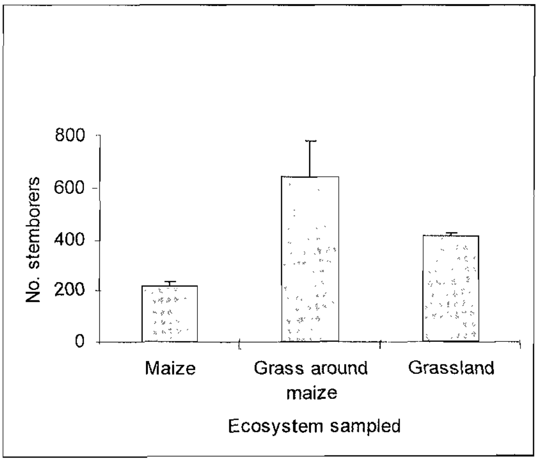

Figure 2. Stemborer populations in maize compared to grass around maize and grassland in Busia district.

TABLE 1. Wild grass hosts of cereal stemborer species recorded in western and eastern Kenya

Grass species	CP	SC	ES	BF	AP	TD	Ms & Mm	Mb	PB	Nsp	CL	Lsp	EM sp. A	EM sp. B	Chilo n. spp.	LB spp.	Smi spp.
Bracharia brizantha	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Cenchrus ciliaris	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Chloris roxybaghiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Coix lacryma	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cymbopogon nardus	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+
Cynodon dactylon	+	-	-	+	+	-	-	-	-	-	-	-	+	+	+	-	-
Digitaria ciliaris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Echinochloa corana	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Echinocloa pyramidalis	+	+	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-
Enteropogon macrstachyus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Eragrostis superba	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Heteropogon contortus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Hyparrhenia cymbaria	+	+	-	+	+	-	+	+	-	-	-	-	-	-	-	-	-
Hyparrhenia filipendula	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-
Hyparrhenia pilgerana	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hyparrhenia rufa	+	+	-	+	+	+	+	+	-	+	-	+	-	-	-	-	-
Panicum maximum	+	+	+	+	+	-	-	-	-	-	-	-	+	+	+	-	-
Panicum deustum	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Pennisetum massaicum	+	+	-	+	-	-	-	-	-	-	-	-	-	-	+	-	-
Pennisetum polystachion	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Pennisetum purpureum	+	+	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Phragmites karka	+	+	-	+	+	-	-	-	-	-	-	-	-	-	+	-	-
Rottboellia cochinchinensis	+	+	-	+	+	-	-	-	-	-	-	-	+	+	+	-	-
Setaria incrassata	+	-	-	+	+	-	-	-	-	-	-	-	-	-	+	+	-
Setaria sphacealata	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Sporobolus pyramidalis	+	-	-	+	+	-	-	-	-	-	-	-	-	-	+	-	-
Sorghum arundinacium	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Sorghum bicolor	+	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-
Sorghum versicolor	+	+	+	+	+	-	-	-	-	-	-	-	+	+	+	-	+
Themeda triandra	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+
Zea mays	+	+	-	+	+	+	-	-	-	+	-	-	-	-	+	-	-

+, recorded as a host; -, not recorded as a host; CP, *Chilo partellus*; ES, *Eldana saccharina*; BF, *Busseola fusca*; AP, *Amphistylus pauli*; TD, *Tanymecus dilaticollis*; Ms & Mm, *Stenalia* sp. A (Mordellidae); Mb, *Stenalia* sp. B (Mordellidae); PB, *Phragmataecia boisduvalli*; Nsp, *Nupserha* nr. *bidentata*; CL, *Cryptophlebia leuctreta*; Lsp., *Lixus* sp.; EM sp. A, *Ematheudes* sp. A; EM sp. B, *Ematheudes* sp. B; *Chilo* n. spp; LB spp., *Languriidae* spp.; Smi, *Smicronyx* spp.

stemborers belonged to two orders: Coleoptera (7 in Curculionidae, 3 in Cerambycidae, 3 Mordillidae, 3 Langridae, 2 Tenebrionidae, 1 Anthribidae) and Lepidoptera (7 Pyralid, 6 Nuctuidae, I Cussidae and I Torticidae). Twenty-three of this grass species were hosts to new stemborers '(Table 2). The highest diversity of new stemborers were from *Panicum maximum* (11 species), *Sorghum versicolor* (10 species), *Hyparrhenia cymbaria* (7 species), *Rottboellia cochinchinensis* (7 species), *Sporobolus pyramidalis* (6 species), *Setaria incrassata* (6 species), *Cynodon dactylon* (6 species), *Echinochloa pyramidalis* (5 species) and *Phragmites karka* (5 species). Whereas most of the grasses haboured the common stemborers (*Busseola fusca*, *Chilo partellus*, *Sesamia calamistis*) with maize and sorghum cereal crops; only *Amphistylus pauli*, *Chilo* n. spp., *Nupserha* nr. *bidentata* and *Tanymecus dilaticolis* among were only resident on maize and sorghum (Table 1). Moreover, during rearing larvae of these species developed well on maize and sorghum stalks.

Stemborer species diversity was highest (15 species) in Busia and lowest (5 species) in Machakos district (Table 2). *Chilo partellus* was the most dominant among cereal crops and wild grasses species in Machakos and Suba districts, while in *Busseola fusca* and *Chilo partellus* were equally dominant in Busia district. *Amphistylus pauli* was dominant in Busia and Suba districts while *Ematheudes* spp. were dominant in Machakos district. Similarly, *Languriid* and *Ceratitis* spp. were dominant in Busia while *Smicronyrx* sp. was dominant in Suba district (Table 2).

The preferred wild grass hosts based on the population of individual stemborer larvae or pupae recovered on each grass species between June 2002 and August 2003 varied with districts. In Busia and Machakos, *Panicum maximum* was the most preferred host while in Suba district it was *Sorghum versicolor*. Both grass species compared favourably with cultivated sorghum and maize in terms of level of infestation (Table 3). Other preferred grass hosts were *Cymbopogon nardus*, *Echinochloa pyramidalis*, *Pennisetum polystachion* and *Hyparrhenia* spp. in Busia; *Rottboellia cochinchinensis*, *E superba*, *C dactylon* and *C ciliaris* in Machakos; while in Suba district it was *H. rufa*, *P. maximum*, *Themeda triandra* and *Panicum deustum*.

The diversity of parasitoids/hyperasitoids, both in terms of family and species, were more than two times higher in the humid Busia district than in the semi-arid Machakos district (Table 4). The number of parasitoid species recovered from grass species alone was far greater than those shared between some wild grasses and cereal crops (maize and sorghum). The stem borer species of *Cotesia*

TABLE 2. Stemborer species occurrence in Busia, Machakos and Suba districts

Stemborer species	Occurrence (%)[1]		
	Busia	Machakos	Suba
Chilo partellus	21.07	52.85	64.84
Chilo n spp.	12.26	-	0.17
Busseola fusca	24.34	0.16	7.59
Sesamia calamistis	4.28	18.48	1.72
Eldana saccharina	13.18	-	0.14
Amphistylus pauli	9.57	-	12.91
Tanymecus dilaticollis	-	-	0.76
Langriid spp. (*Nadasstus* + *Barbaropus*)	4.32	0.06	0.52
Smicronyrx sp.	0.10	-	2.80
Stenalia spp.	1.12	-	0.14
Nupserha	0.14	-	-
Ematheudes spp.	2.01	9.72	-
Phagmataeciaa biosduvalii	1.65	-	-
Ceratitis	3.86	-	-
Cucujidae	0.47	-	-
Cryptophlebia leucotreta	0.24	-	-
Mixture of pyralid and noctuid larvae	11.99	-	8.49

[1]Occurence refers to number of borers recovered for each species as a percentage of the total number of borers recovered for all species in a site

flavipe, *Dentichasmias busseolae*, *Aphanogmus fujiensis*, *Mermis* sp, *Amyosoma chinensis* and *Stenobracon* sp. were only associated with cereal crops. Those that were shared between some wild grass species and cereal crops included: *Cotesia sesamiae*, *Pediobius furvus*, *Tetrastichus* sp, *Eurytoma* sp, *Siphoniini* sp, and *Habracon*; while, over 25 species were associated with grasses only (Table 4).

DISCUSSION

This study has demostrated that species diversity for both stemborer and parasitoid was higher in the wetter district of Busia than in Machakos. This may be attributed to the fact that the wetter districts provide a higher spatial and temporal continuity of suitable hosts for maintaining active feeding and reproduction thereby increasing the borer population; whereas in the drier districts, some grass host may be too dry during off-season cropping period to serve as suitable host (shelter for survival) feeding and or oviposiotn for the larvae. These results are in agreement with those of Zhou *et al.* (2003), who reported low stemborer and parasitoid populations in the drier district of Taita Taveta when compared with wetter districts at the Coastal region of Kenya.

Of the new stemborer species, only *Amphistylus pauli*, *Chilo* n. spp, *Nuspserha* nr. *bidentata* and *Tanymecus dilaticolis* were shared with either maize or sorghum. However, when reared on maize or sorghum stalks all the larvae of new stemborer species developed well. This observation suggests that these borers could become potential pests of maize and sorghum. The study also showed that only a few of the parasitoids species (*Cotesia sesamiae, Habracon*

TABLE 3. Stemborer population occurrence on the cereal crop and grass species in Busia, Machakos and Suba districts

Gramminaea species	Stemborer population (% occurrence)[2]		
	Busia	Machakos	Suba
Zea mays	15.02	35.46	29.69
Sorghum bicolor	46.88	14.23	18.09
Sorghum versicolor	4.72	-	18.94
Panicum maximum	37.41	30.70	8.78
Cymbopogon nardus	15.61	-	2.13
Echinochloa coracana	1.48	-	-
Echinochloa pyramidalis	8.61	-	-
Rottboellia cochinchinensis	3.03	15.21	0.12
Pennisetum polystachion	7.23	-	-
Pennisetum purpureum	0.49	0.11	-
Sacchacrum officinarum	0.02	-	-
Setaria sphacealata	0.66	-	0.72
Setaria incrassata	-	-	2.67
Sporobolus pyramidalis	1.38	0.72	0.26
Phragmites karka	0.16	00	00
Cynodon dactylon	0.48	3.45	1.30
Loudetia arundinacea	0.01	-	-
Hyparrhenia cymbaria	2.55	-	1.73
Hyparrhenia filipendula	-	-	1.61
Hyparrhenia pilgerana	-	-	-
Hyparrhenia rufa	0.55	0.18	10.58
Imperata cylindrica	1.00	-	1.73
Coix lacryma jobi	0.08	-	-
Themeda triandra	-	1.83	2.67
Panicum deustum	-	0.47	2.71
Pennisetum masaicum	-	0.02	-
Eragrostis superba	-	5.09	0.71
Cenchrus ciliaris	-	3.04	-
Chloris roxybaghiana	-	1.75	-
Sorghum arundinaceum	-	0.38	-
Heteropogon contortus	-	0.01	-
Enteropogon macrostychus	-	0.30	-
Cyprus immaculatus	0.52	-	-
Digitaria ciliaris	-	0.03	-

[2]Refers to stemborer population for each grass species as a percentage of total stemborers for all grass hosts at each site

TABLE 4. Diversity of stemborer parasitoids associated with grass species in western and eastern Kenya

Grass species	Stemborer host	Associated parasitoids
Busia district (Western Kenya)		
Zea mays (maize)	*Chilo partellus*	Cotesia sesamiae [Braconidae]* Pediobius furvus [Eulophidae]* Tetrastichus sp. [Eulophilidae]
	Chilo n. sp.	Mermis sp [Mermithidae]*
	Busseola fusca	Aphanogmus fijiensis [Ceraphronidae] Cotesia sesamiae [Braconidae]* Dentichasmias busseolae [Ichneumonidae]*
		Eurytoma sp. [Eurytomidae]*
Sorghum bicolor (sorghum)	*Chilo partellus*	Aphanogmus fijiensis [Ceraphronidae]** Cotesia sesamiae [Braconidae]* Dentichasmias busseolae [Ichneumonidae]* Pediobius furvus [Eulophidae]* Hockeria [Chalcidae]*
Cynodon dactylon	*Busseola fusca*	Cotessia sesamiae [Braconidae]* Eurytomidae
Cymbopogon nardus	*Chilo partellus*	Dolichogenidea polaszeki [Braconidae]* Eurytomidae A. [Eurytomidae]
	Chilo n. sp	Siphoniini sp. [Tachnidae]*
	Busseola fusca	Sycophila sp. [Eurytomidae] Sturmiopsis sp. [Tachinidae] Tetrastichus sp. [Eulophilidae] Pteromalid sp. [Pteromalidae] Megaselia spp. [Phoridae] Inostenima nr. senegalensis [Platygasteridae]
	Smicronyx	Sycophila sp. [Eurytomidae]
Echinochloa pyramidalis	*Amphistylus pauli*	Mymaridae*
	Chilo partellus	Cotesia sesamiae [Braconidae]*
	Chilo partellus	Habrobracon [Braconidae]* Tetrastichus howardii [Eulophilidae] Platygaster sp. A [Platygastenidae]
Hyparrhenia rufa		Bracon testaceorufatus [Braconidae]* Bracon sp [Braconidae] Eurytoma braconidis [Eurytomidae] Pteromalidae sp. A [Pteromalidae]
Hyparrhenia schemperi	*Amphistylus pauli*	Eurytoma braconidis [Eurytomidae] Pteromalidae sp. A [Pteromalidae] Megaselia sp. [Phoridae]
Panicum maximum	*Chilo partellus*	Descampsina sesamiae [Tachinidae]*
Pennisetum purpureum	*Chilo partellus*	Pediobius furvus [Eulophidae]* Scelio sp. [Scelionidae]
Rottboellia cochinchinensis		Tetrastichomyia [Eulophidae] Tetrastichus sp. [Eulophidae]
Sporobolus pyramidalis	*Amphistylus pauli*	Aprostocetus sp. [Eulophidae] Inostemma sp [Platygasteridae]

TABLE 4. Contd.

Grass species	Stemborer host	Associated parasitoids
		Scelio sp. [Scelionidae] Eurytoma braconidis [Eurytomidae] Platygaster sp. [Platygasteridae] Tetrasticus sp. [Eulophidae] Inostenima nr. senegalensis [Platygasteridae] Psilochalcis soudanensis [Chalcididae] Aprostocerus sp. [[Eulophidae]
Suba district (western Kenya)		
Zea mays (maize)	*Chilo partellus*	Cotesia flavipes [Braconidae]* Amyosoma chinensis [Braconidae]* Siphoniini [Tachinidae]*
Sorghum bicolor	*Chilo partellus*	Cotesia seamiae [Braconidae]* Habrobracon [Braconidae]* Stenobracon [Braconidae]* Dentichasmias busseolae [Ichneumonidae]*
Hyparrhenia rufa	*Busseola fusca*	Psilochalsis soudanensis [Chalcididae] Descampsina sesamiae [Trachinidae]
	Atherigona sp.	Psilochalsis sp. [Chalcididae]
	Eldana sacharina	Dasyproctus sp. [Spheridae]***
Panicum maximum	*Amphistylus pauli*	Rharonotus sp. [Braconidae]
	Chilo partellus	Stenobracon [Braconidae] Cotesia seamiae [Braconidae] Syzeutus sp. [Ichneumonidae]* Eurytoma sp. [Eurytomidae]
	Smicronyx sp.	Pteromalidae
Sorghum versicolor	*Amphistylus pauli* *Busseola fusca*	Gonotocerus sp. [Mymaridae]* Cotesia flavipes [Braconidae]* Platydexia sp. [Tachnidae] *
	Chilo partellus	Cotesia sesamiae [Braconidae]* Platydexia sp. [Tachnidae]* Pediobius furvus [Eulophidae]*
	Chilo n. sp.	Cotesia sesamiae [Braconidae]* Platydexia sp. [Tachnidae]* Syzeuctus sp. [Ichneumonidae]* Trichogramma sp. [Trichgrammatidae]
	Smicronyx	Braconidae*
Machakos district (Eastern)		
Zea mays (maize)	*Chilo partellus*	Cotesia seamiae [Braconidae]* Dentichasmias busseolae [Braconidae]* Pediobius furvus [Eulophidae]*
	Seasmiae calamistis	Pediobius furvus [Eulophidae]* Cotesia seamiae [Braconidae]*

TABLE 4. Contd.

Grass species	Stemborer host	Associated parasitoids
Cynodon dactylon	*Ematheudes* sp.	Venturia sp. [Ichneuminidae]*
	Chilo partellus	Cotesia sesamiae [Braconidae]*
Enteropogon macrostychus	*Chilo partellus*	Cotesia sesamiae [Braconidae]*
Panicum maximum	*Ematheudes* sp.	Holcopimpla [Ichneumonidae]*
	Chilo partellus	Goniozus indicus [Bethylidae]*
Rottboellia cochinchinensis	*Ematheudes* sp.	Bracon sp. [Braconidae]* Cotesia sesamiae [Braconidae] Dolichogenidea polszeki Walker [Braconidae] Habrobracon sp. [Braconidae]* Protopanteles sp. [Braconidae] Eurytoma sp. [Eurytomidae] Venturia sp. n. 2 [Ichneumonidae]*
Sorghum arundinacium	Cocoons	Dasyproctus sp. [Sphecidae] Tetrastichus sp. [Eulophidae]**

* Confirmed parasitoids; ** Confirmed hyperparasitoids; *** Found as a predator living in grass stems

sp, *Pediobius furvus, Tetrastichus* sp, *Eurytoma* sp *and Siphoniini* sp) associated with grasses were resident on both maize and sorghum; the majority were specific to other grass species. Grass species with the highest diversity of parasitoids species also differed between districts and suggests host preference for many of the stemborers. This further suggests that extinction will result in loss of stemborer natural enemies, with potential deleterious repercussions to both wild and cultivated ecosystems.

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REFERENCES

Boonman, J.G. 1992. Tropical grasses from the East African centre of biodiversity. *Biotechnology and Development Monitor* 11:1-10.

Bowden, J. 1976. Stemborer ecology and strategy for control. *Annals of Applied Biology* 84:107-134.

Dwumfour, E.F. 1990. Predators of *Chilo partellus*. In: *International Centre of Insect Physiology and Ecology (ICIPE)*. 18th Annual Report, ICIPE, NAIROBI. pp. 32-36.

Jaetzold, R. and Schmidt, H. 1982a. Farm Management Handbook of Kenya. Vol. II/A. western Kenya. Ministry of Agriculture, Kenya. 397pp.

Jaetzold, R. and Schmidt, H. 1982b. Farm Management Handbook of Kenya. Vol. II/C. East Kenya. Ministry of Agriculture, Kenya. 411pp.

Ibrahim, K.M. and Kabuye, C.H.S. 1988. An Illustrated Manual of Kenya Grasses. FAO, Rome, Italy. 765pp.

Khan, Z.R., Chiliswa, P., Ampong-Nyarko, K., Smart, L.E., Polazzeki, A., Wandra, J. and Mulaa, M.A. 1977a. Utilization of wild graminaceous plants for management of cereal stemborers in Africa. *Insect Science and Application* 17: 143-150.

Kan, Z.R., Ampong-Nyarko, K., Chiliswa, P., hassanali, A., Kimani, S., Lwande, W., Overholt, W.A., Pickett, J.A., Smart, L.E., Wadhams, L.J. and Woodcock, C.M. 1977b. Intercropping increases parasitism of pests. *Nature* 388:631-632.

Khan, Z.R., Pickett, J.A. and van den Berg J., Wadhams, L.J. and Woodcock, C.M. 2000. Exploiting chemical ecology and species diversity: Stemborer and striga control for maize and sorghum in africa. *Pest Management Science* 56:957-962.

Khan, Z.R., Pickett, J.A., wadhams, L. and Muyekho, F. 2001. Habitat management strategies for the control of cereal stemborers and *Striga* in maize in Kenya. *Insect Science and Application* 21:375-380.

Mohyuddin, A.I. and Greathead, D.J. 1970. Annoted list of parasites of graminaceous stemborers in east Africa, with a discussion of their potential in biological control. *Entomophaga* 15:241-274.

SAS Institute, 1977. SAS/STAT software. Changes and enhancements through release 6.12. Cary, North Carolina, USA.

Shanower, T.G., Schulthess, F. and Bosque-P'erez, N.A. 1993. The effect of larval diet on development of *Sesamiae calamistis* Hampton (Lepidoptera:Nuctuidae). *Insect Science and Application* 14:681-685.

Van den Berg, J., Rebe, M., De Bruyn, J. and van Hamburg, H. 2001. Developing habitat management systems for graminaceous stemborers in South Africa. *Insect Science and Application* 21:381-388.

Zhou, G., Overholt, W.A. and Kimani-Njogu, S.W. 2003. Species richness and parasitism in assemblage of parasitoids attacking maize stemborers in Coastal Kenya. *Ecological Entomology*